

IAEA GUIDANCE ON ENVIRONMENTAL IMPACT ASSESSMENT FOR NUCLEAR INSTALLATIONS

*Asian Nuclear Safety Network (ANSN)
Regional Workshop on Radiological Environmental Impact Assessment for
Nuclear Installations
Hosted by the Government of the Philippines through the Philippine Nuclear Research Institute (PNRI)
Manila, Philippines, 24–28 October 2022*

Outline

- Introduction
- Siting Process for Nuclear Installation
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- Typical Table of Contents SAR
- IAEA Safety Standards related to EIA
- Radiological environmental impact assessment
- Typical Content of the Environmental Scoping Report
- Typical Content of the Environmental Impact Assessment Report

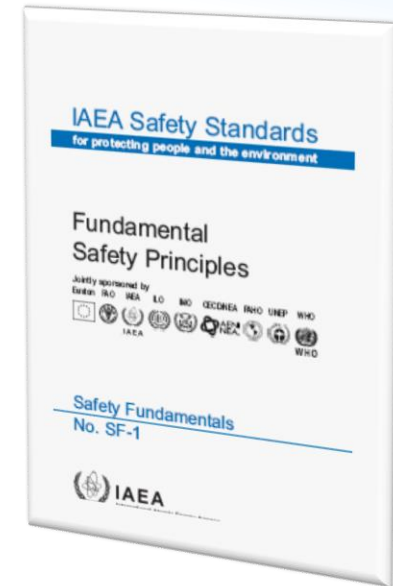
Introduction

- 1 Safety Objective:

“The fundamental safety objective is to protect people and the environment from the harmful effects of ionizing radiation”

- 10 Fundamental Safety Principles:

1. Responsibility for Safety
2. Role of Government
3. Leadership and Management for Safety
4. Justification of Facilities and Activities
5. Optimization of Protection
6. Limitation of Risks to Individuals
7. Protection of present and Future Generations
- 8. Prevention of Accidents**
- 9. Emergency Preparedness and Response**
10. Protective action to reduce existing or unregulated Radiation Risks



The hierarchy



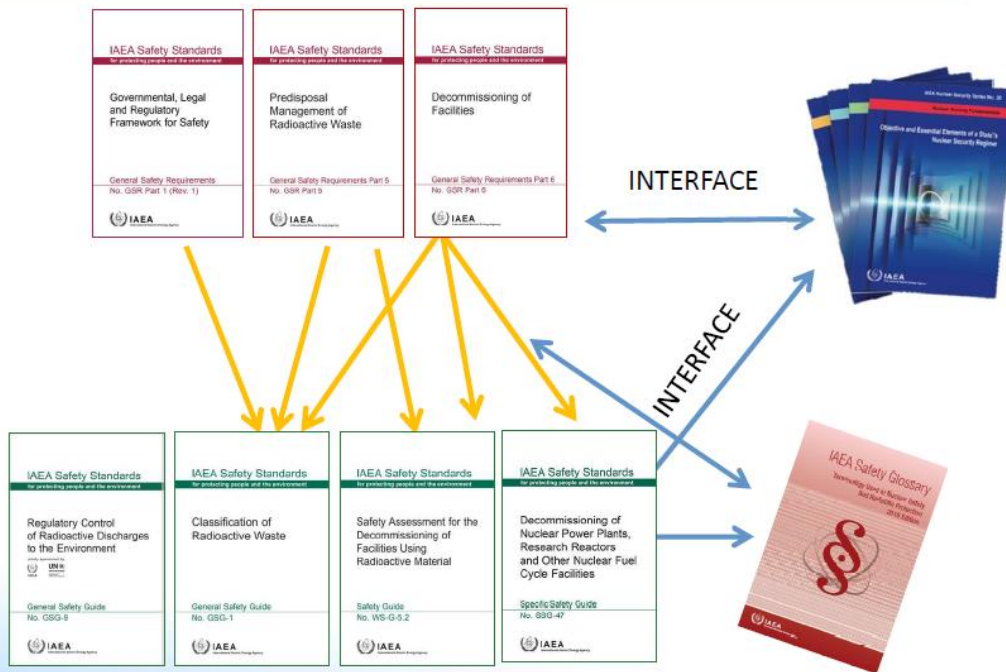
Fundamental safety objective and ten principles for protecting people and environment

Requirements that have to be met to ensure protection of people and environment

Recommendations on how to comply with the safety requirements

Relationship in Safety Standards

The safety standards are a set of publications.
They are consistent with one another
and are interrelated.



Publications in the IAEA Nuclear Security Series provide recommendations and guidance on nuclear security and are consistent with the safety standards

Introduction

Principle 8 – Prevention of Accidents

- The primary means of preventing and mitigating the consequences of accidents is “defence in depth” concept.
- The “**Defence in Depth (DID)**” is implemented through a combination of consecutive and independent levels of protection. . .

“**DID**” is provided by combination of:

- Effective management system
- **Selection of suitable site and proper characterization selected site**, good design and engineering safety features providing safety margins, diversity and redundancy.
- Comprehensive operational procedures and practices.

Introduction

The site area is the geographical area that contains an authorized facility, and within which the management of the authorized facility may directly initiate emergency actions.



Introduction

The licensing process for a nuclear installation normally includes the following stages, depending on national legislation:

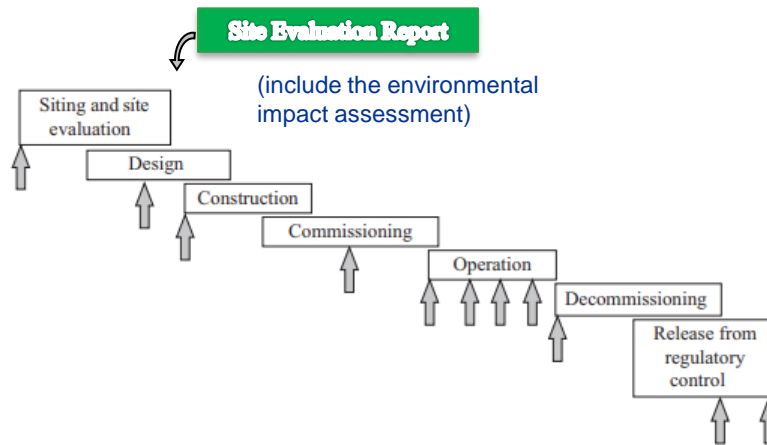
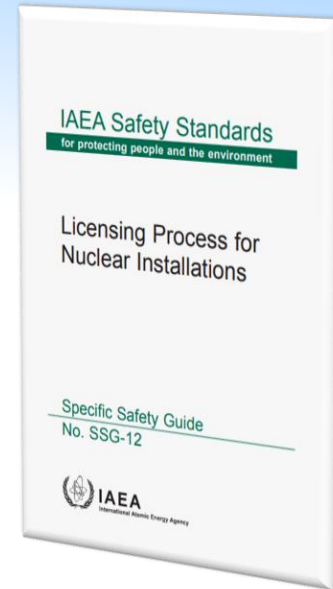


FIG. 1. Stages in the lifetime of a nuclear installation; the arrows indicate where hold points may be imposed.

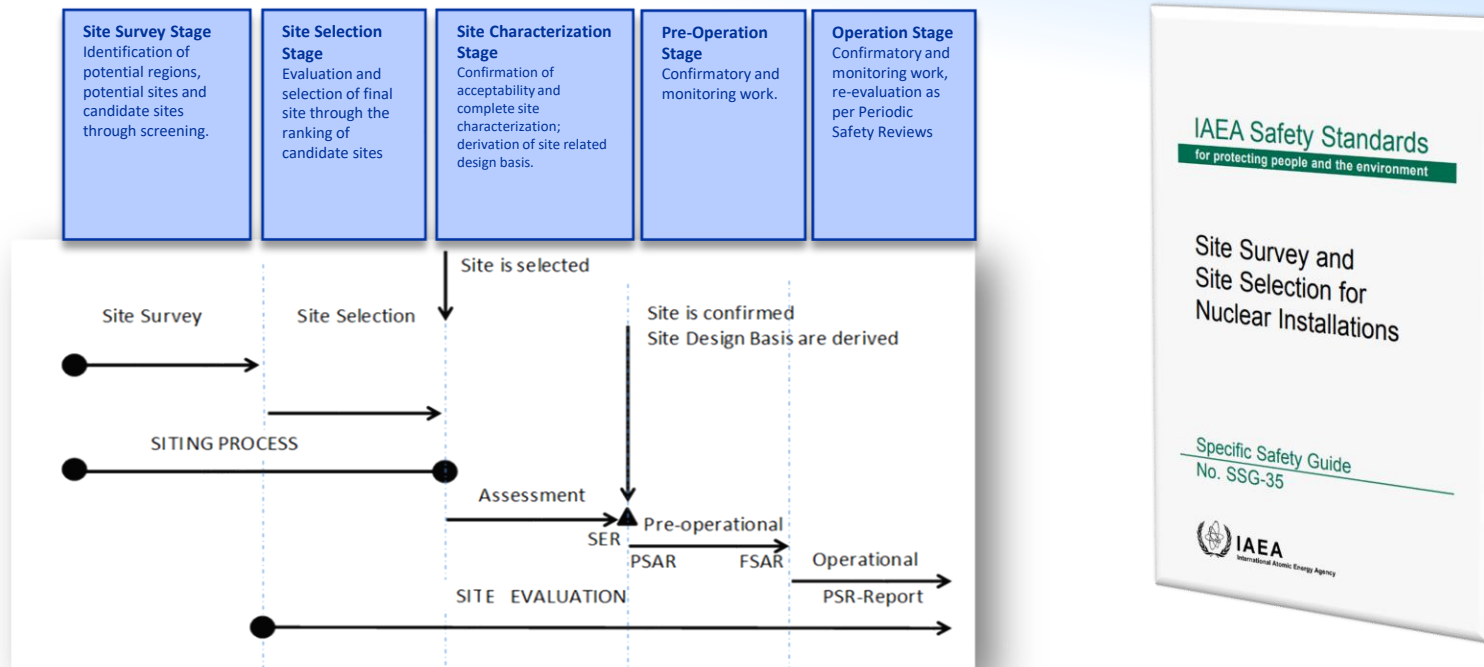


IAEA



The arrows indicate where hold points may be imposed.

Introduction



Introduction

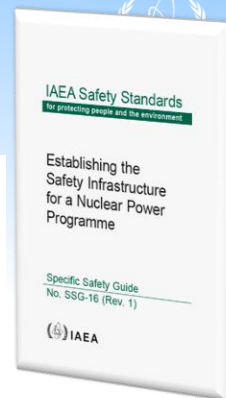
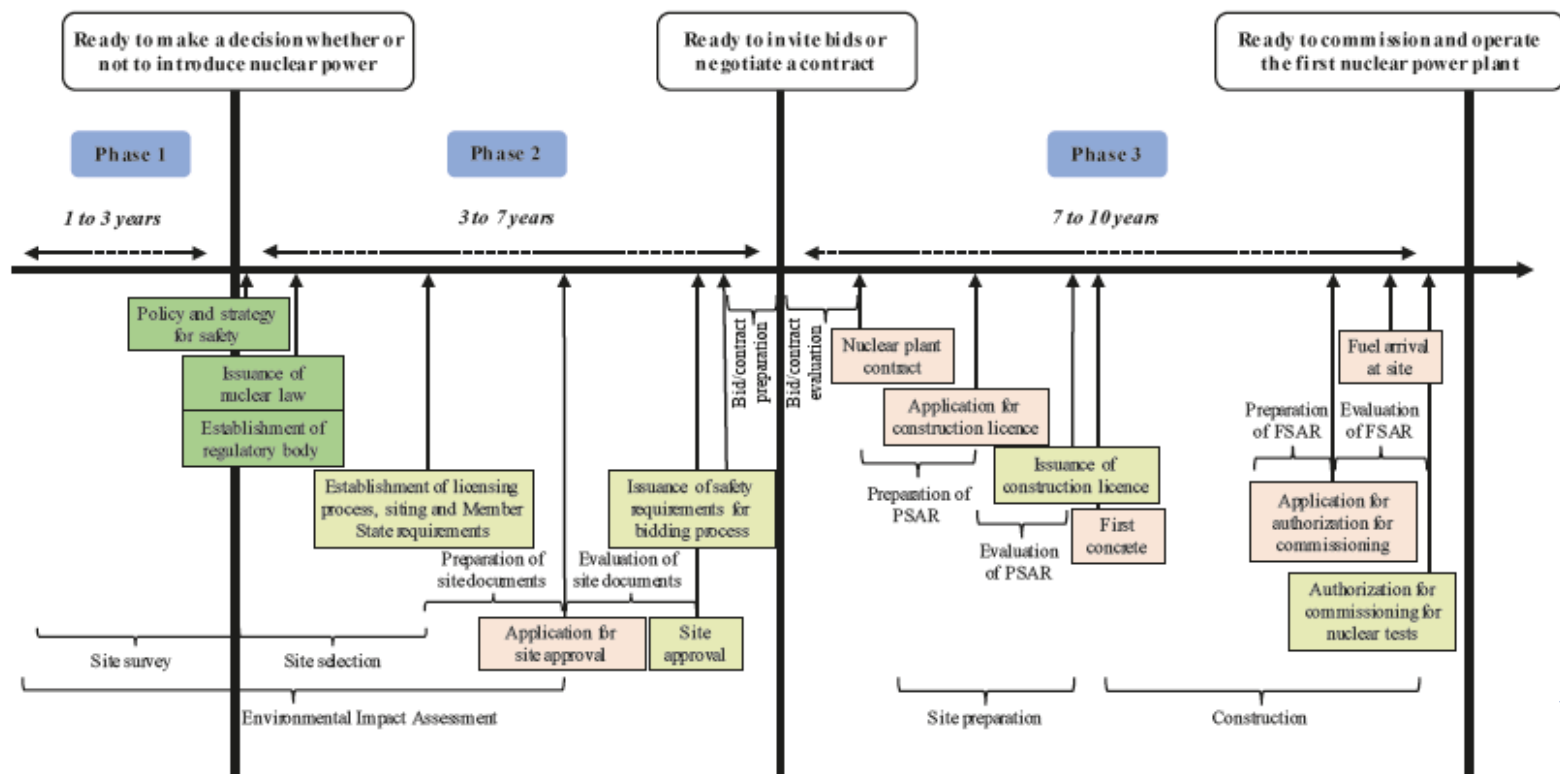


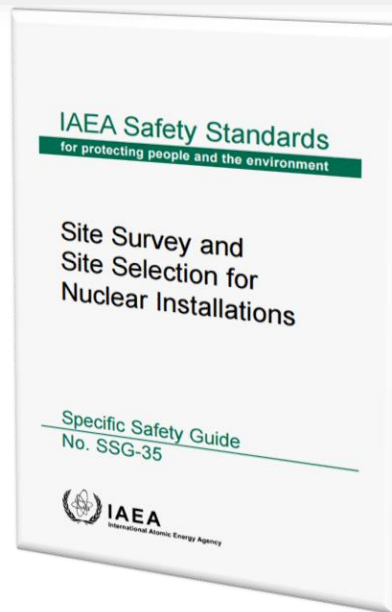
FIG. 2. Indicative time frame and some important milestones for the development of a nuclear safety infrastructure.

Siting Process for Nuclear Installation

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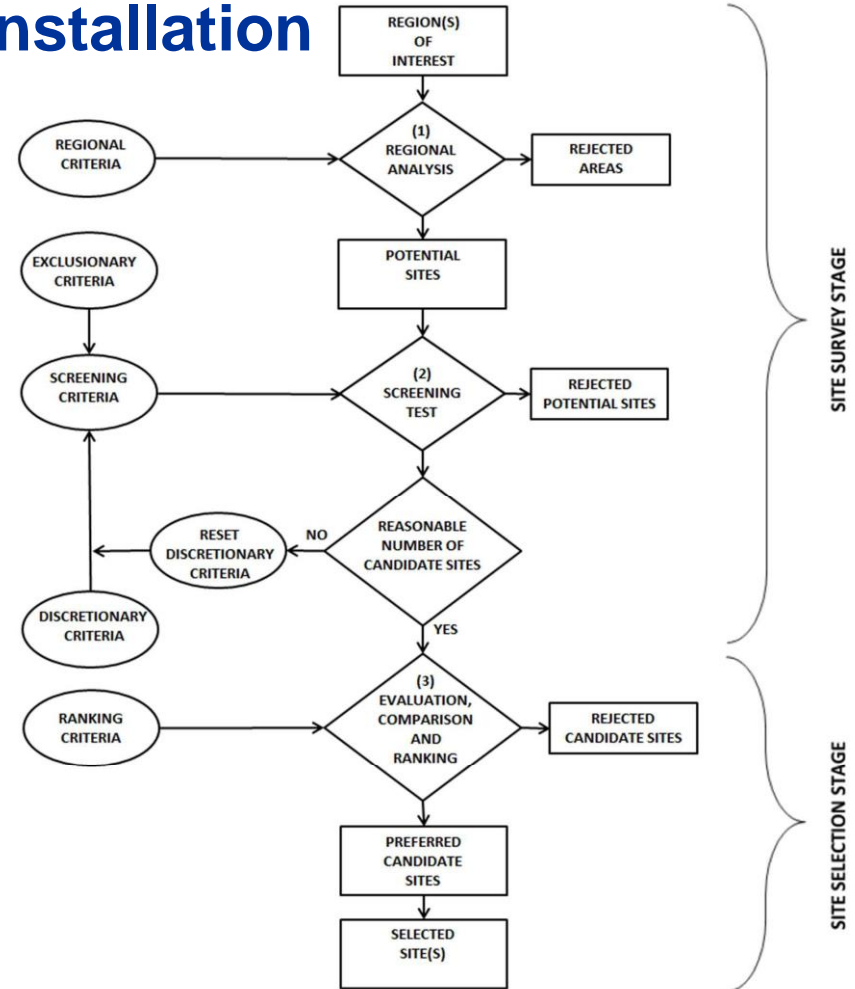
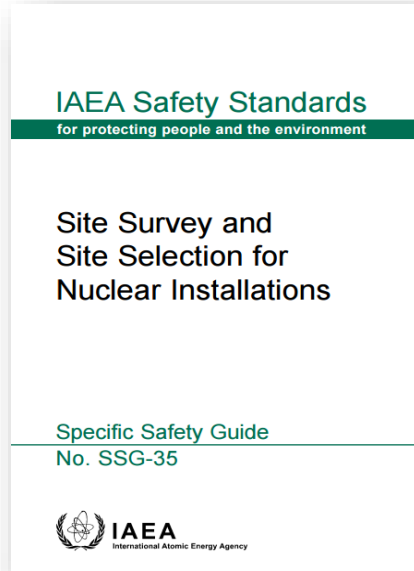
Siting Process for Nuclear Installation

- In most Members States, Siting is a non-regulated activity and no licence is required.

Needs of clear criteria and regulatory requirements

- The site selection process needs to be guided by a clearly established set of criteria or regulatory requirements.
- This is of particular importance for those aspects that can exclude sites.
 - Earthquake: Surface rupture
 - Geotechnical: Slope instability (massive landslides), massive liquefactions, karst (massive)
 - Volcanism: Lava flow, pyroclastic flow, ground deformation, lahars
 - Feasibility of implementation of emergency plan
 - etc.

Siting Process for Nuclear Installation



Siting Process for Nuclear Installation

NPP Site Selection

Comparison and ranking of candidate sites

- Site Merit Calculation

$$SM = \sum_{i=1}^n \left[W_i \sum_{j=1}^{b_i} W_{ij} R_{ij} \right]$$

SM Site merit

i Criterion group number

W_i Criterion group weighting factor

j Criterion number

b_i Number of criterion in criterion group i

W_{ij} Weighting factor for criterion j in criterion group i

R_{ij} Rating assigned to a potential site for criterion j in criterion group i

- The differential cost or cost–benefit estimation with respect to a non-site-specific generic design bounding envelop.

Role & Responsibility during Site Licensing

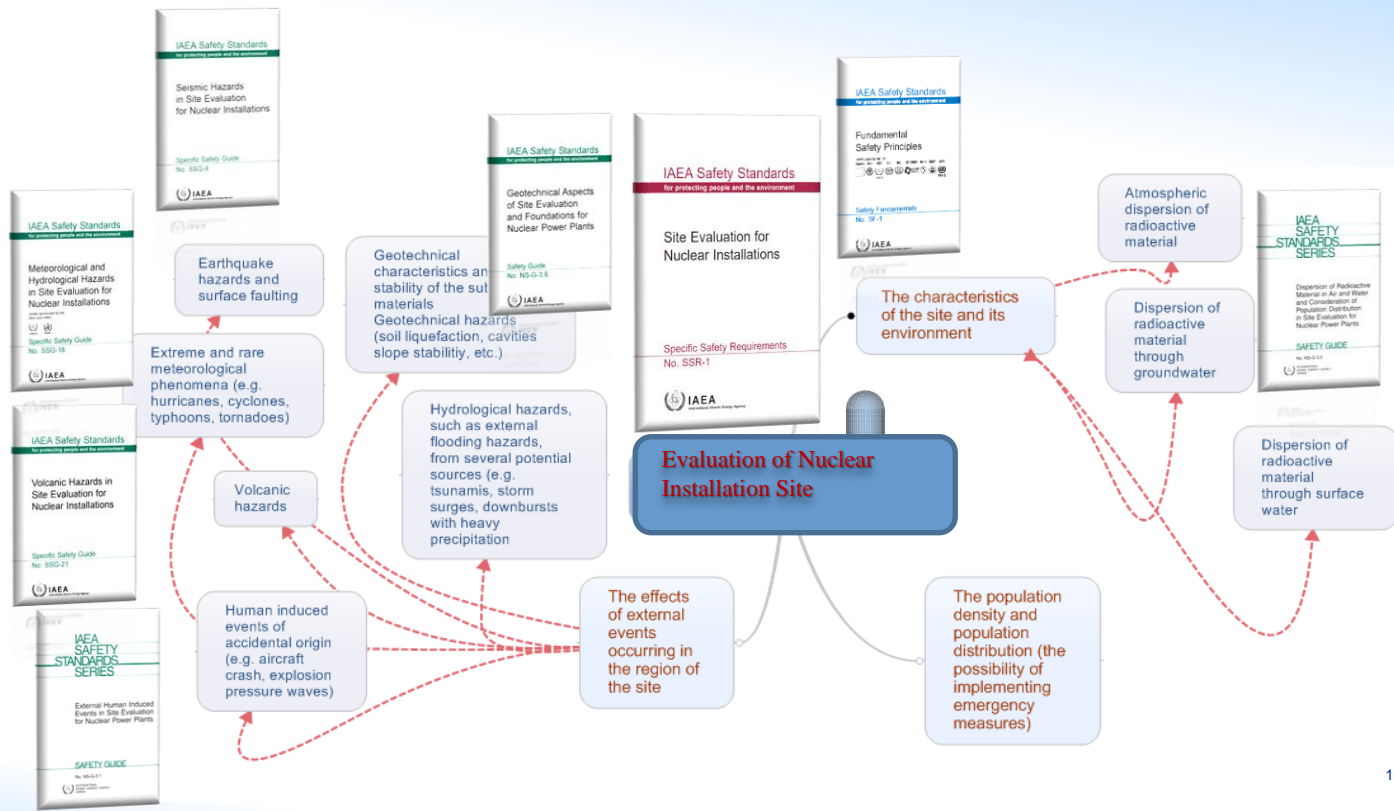
Regulatory Body's (RB) responsibilities;

- ✓ Define licensing stage, sub-stage for site licensing,
- ✓ Define the safety criteria, requirements, guidelines,
- ✓ Define the documents to be provided by the operating organization,
- ✓ Define the review & assessment, inspection and enforcement processes,
- ✓ Establish a mechanism to solve safety issues with the operating organization,
- ✓ Make a decision on licence application,
- ✓ Identify the licence conditions.

The operating organization's responsibilities;

- ✓ Select a suitable site for NPP
- ✓ Notify the RB on site selection,
- ✓ Submit the site investigation work programme to RB for inspections,
- ✓ Apply the management system for site evaluation activities,
- ✓ Conduct the detailed site investigation,
- ✓ Establish monitoring programme and start monitoring,
- ✓ Conduct the work for environmental impact assessment,
- ✓ Ready to be inspected by RB,
- ✓ Prepare and submit the required documentations for site licensing,
- ✓ Be prepared to respond to the requests of the RB,
- ✓ Comply with the site licence conditions after obtaining site licence.

IAEA Safety Standards Related to Site Evaluation



Site Evaluation Requirements

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IAEA Safety Standards

for protecting people and the environment

Site Evaluation for Nuclear Installations

Specific Safety Requirements

No. SSR-1

Requirement 1: Safety objective in site evaluation for nuclear installations

The safety objective in site evaluation for nuclear installations shall be to characterize the natural and human induced external hazards that might affect the safety of the nuclear installation, in order to provide adequate input for demonstration of protection of people and the environment from harmful effects of ionizing radiation.

Requirement 2: Application of the management system for site evaluation

Site evaluation shall be conducted in a comprehensive, systematic, planned and documented manner in accordance with a management system.

Requirement 3: Scope of the site evaluation for nuclear installations

The scope of the site evaluation shall encompass factors relating to the site and factors relating to the interaction between the site and the installation, for all operational states and accident conditions, including accidents that could warrant emergency response actions.

Requirement 4: Site suitability

The suitability of the site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear installation.

Requirement 5: Site and regional characteristics

The site and the region shall be investigated with regard to the characteristics that could affect the safety of the nuclear installation and the potential radiological impact of the nuclear installation on people and the environment.

Requirement 6: Identification of site specific hazards

Potential external hazards associated with natural phenomena, human induced events and human activities that could affect the region shall be identified through a screening process.

Requirement 7: Evaluation of natural and human induced extremal hazards

The impact of natural and human induced external hazards on the safety of the nuclear installation shall be evaluated over the lifetime of the nuclear installation.

Requirement 8: Measures for site protection

If the projected design of the nuclear installation is not able to safely withstand the impact of external natural and human induced hazards, the need for site protection measures shall be evaluated.

Requirement 9: Site evaluation for multiple nuclear installations on the same site or on adjacent sites

The site evaluation shall consider the potential for natural and human induced external hazards to affect multiple nuclear installations on the same site as well as on adjacent sites.

Requirement 10: Changes of hazards and site characterizations with time

The external hazards and the site characteristics shall be assessed in terms of their potential for changing over time and the potential impact of these changes shall be evaluated.

Requirement 11: Special considerations for the ultimate heat sink for nuclear installations that require an ultimate heat sink

The evaluation of site specific natural and human induced external hazards for nuclear installations that require an ultimate heat sink shall consider hazards that could affect the availability and reliability of the ultimate heat sink.

Requirement 12: Potential effects of the nuclear installation on people and the environment

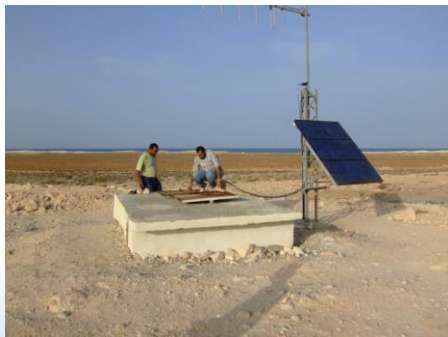
In determining the potential radiological impact of the nuclear installation on the region for operational states and accident conditions, including accidents that could warrant emergency response actions, appropriate estimates shall be made of the potential releases of radioactive material, with account taken of the design of the nuclear installation and its safety features.

Requirement 13: Feasibility of planning effective response actions

The feasibility of planning effective emergency response actions on the site and in the external zone shall be evaluated, with account taken of the characteristics of the site and the external zone as well as any external events that could hinder the establishment of complete emergency arrangements prior to operation.

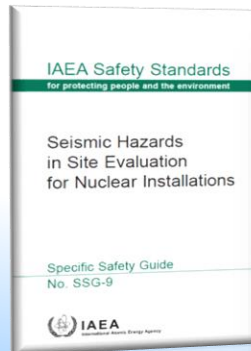
Requirement 14: Data collection in site evaluation for nuclear installations

The data necessary to perform an assessment of natural and human induced external hazards and to assess both the impact of the environment on the nuclear installation safety and the impact of the nuclear installation on people and the environment shall be collected.



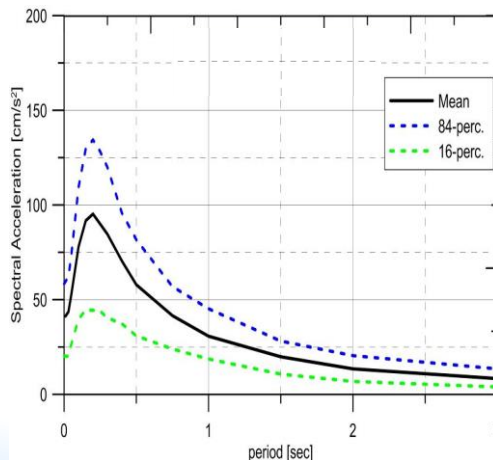
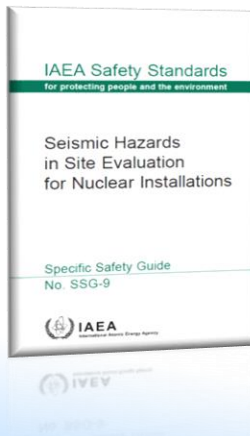
Requirement 15: Evaluation of fault capability

Geological faults larger than a certain size and within a certain distance of the site and that are significant to safety shall be evaluated to identify whether these faults are to be considered capable faults. For capable faults, potential challenges to the safety of the nuclear installation in terms of ground motion and/or fault displacement hazards shall be evaluated.

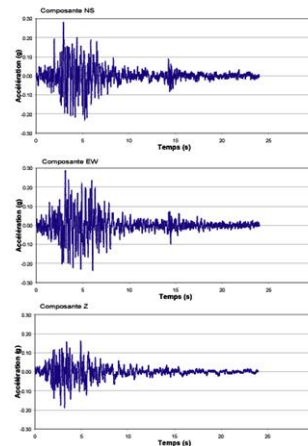


Requirement 16: Evaluation of ground motion hazards

An evaluation of ground motion hazards shall be conducted to provide the input needed for the seismic design or safety upgrading of the structures, systems and components of the nuclear installation, as well as the input for performing the deterministic and/or probabilistic safety analyses necessary during the lifetime of the nuclear installation.



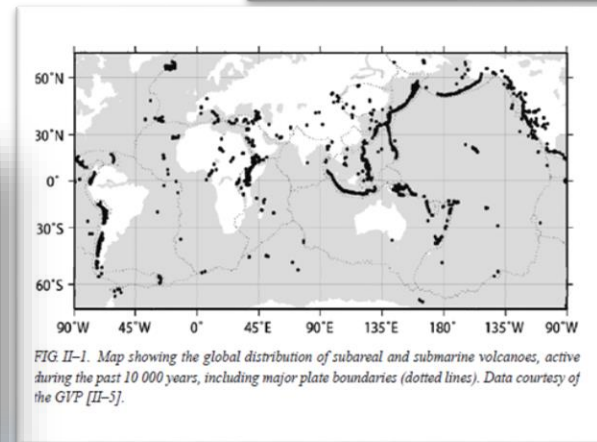
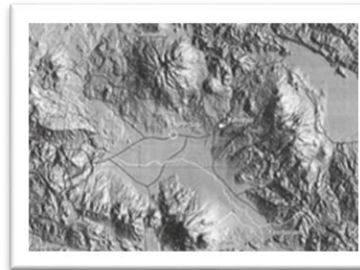
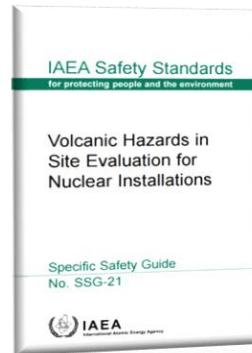
Uniform Hazard Spectra



Time histories

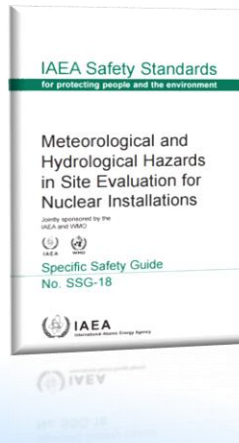
Requirement 17: Evaluation of volcanic hazards

Hazards due to volcanic activity that have the potential to affect the safety of the nuclear installation shall be evaluated.



Requirement 18: Evaluation of extreme meteorological hazards

Extreme meteorological hazards and their possible combinations that have the potential to affect the safety of the nuclear installation shall be evaluated.



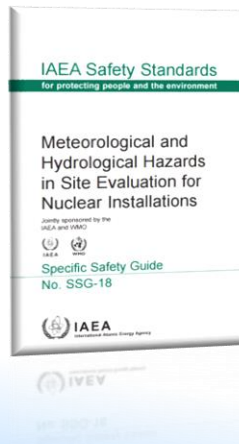
High Wind Speed Missiles



Waterspouts

Requirement 19: Evaluation of rare meteorological events

The potential for the occurrence of rare meteorological events such as lightning, tornadoes and cyclones, including information on their severity and frequency, shall be evaluated.

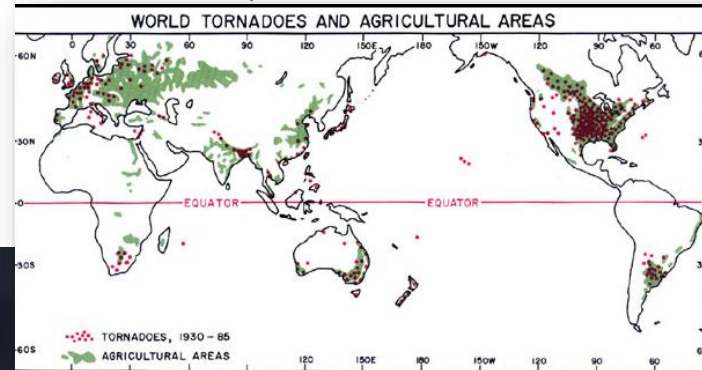


Tornadoes



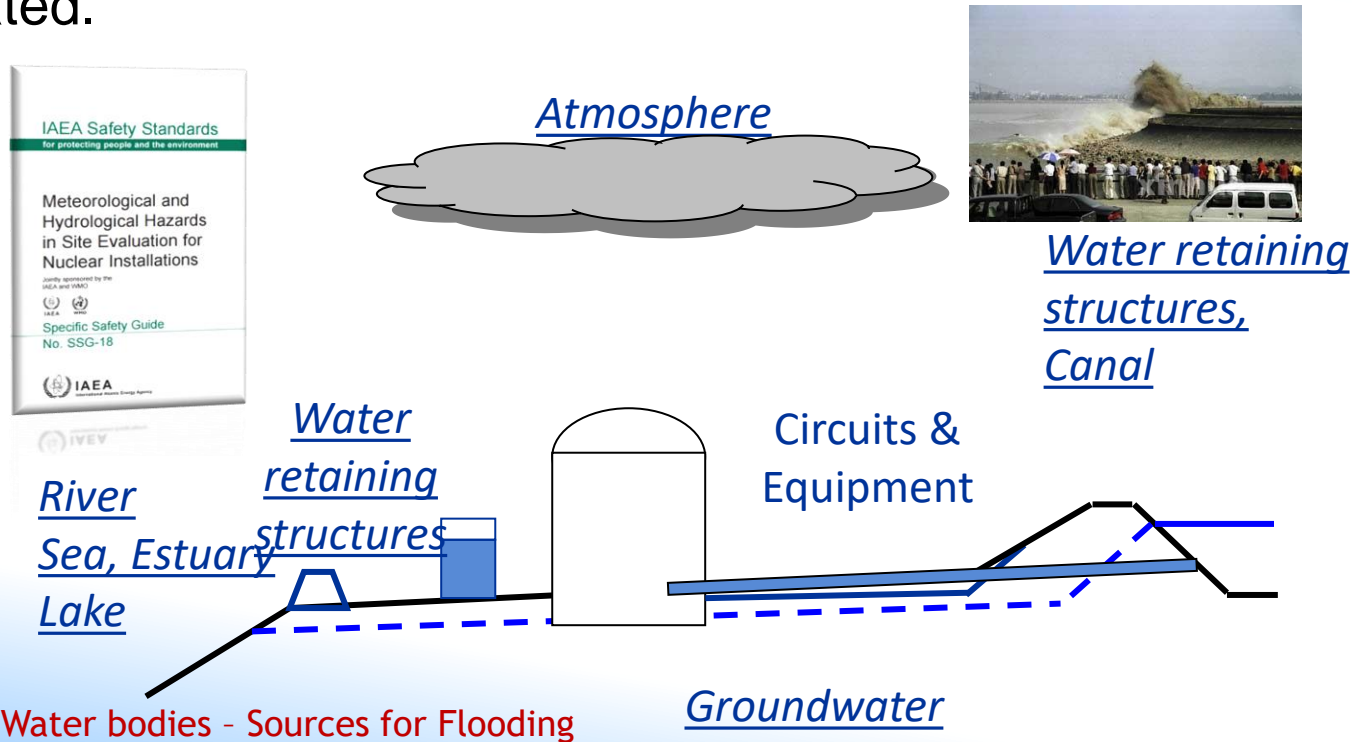
Lightning

World Map of Tornado Occurrence



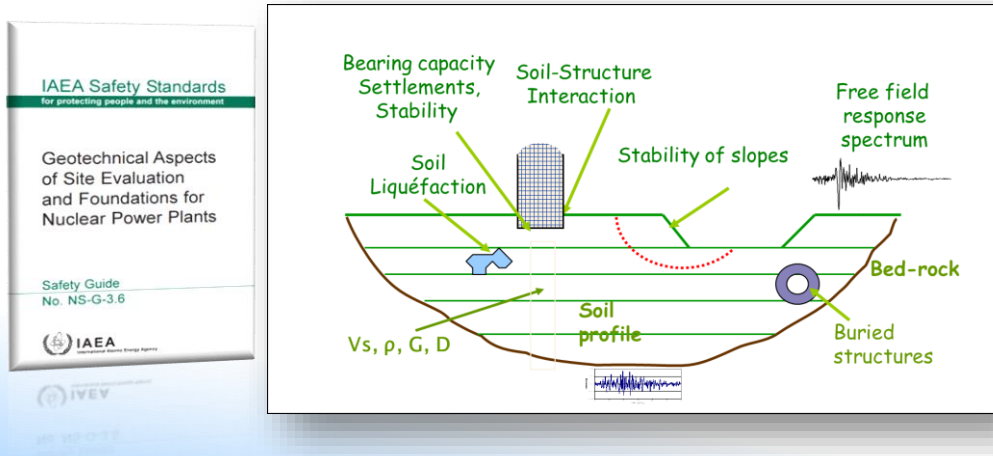
Requirement 20: Evaluation of flooding hazards

Hazards due to flooding, considering natural and human induced events including their possible combinations, shall be evaluated.



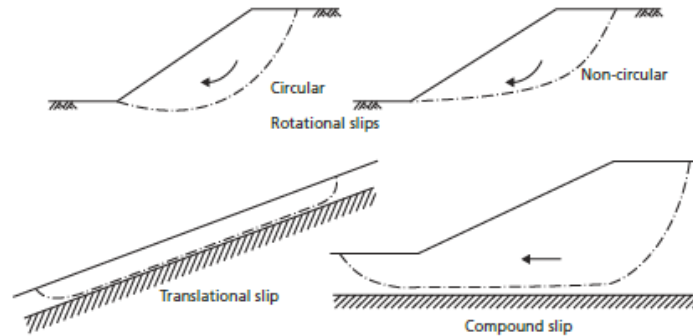
Requirement 21: Geotechnical characteristics and geological features of subsurface materials

The geotechnical characteristics and geological features of subsurface materials shall be investigated, and a soil and rock profile for the site that considers the variability and uncertainty in subsurface materials shall be derived.



Requirement 22: Evaluation of geotechnical hazards and geological hazards

Geotechnical hazards and geological hazards, including slope instability, collapse, subsidence or uplift, and soil liquefaction, and their effect on the safety of the nuclear installation, shall be evaluated.



Failure Modes of slopes

Requirement 23: Evaluation of other natural hazards

Other natural phenomena that are specific to the region and which have the potential to affect the safety of the nuclear installation shall be investigated.



Dust Storms and Sandstorms



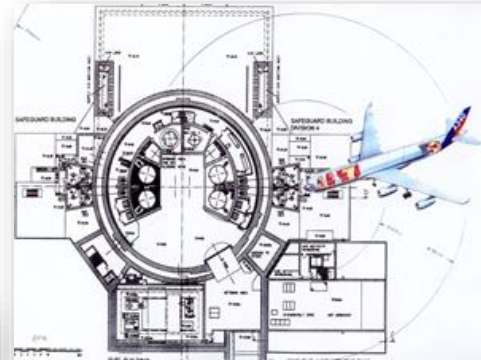
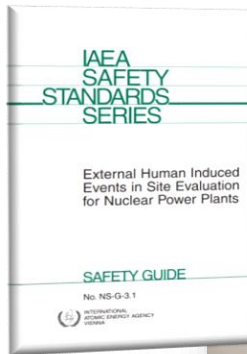
Hail



Freezing Precipitation - Ice Storm

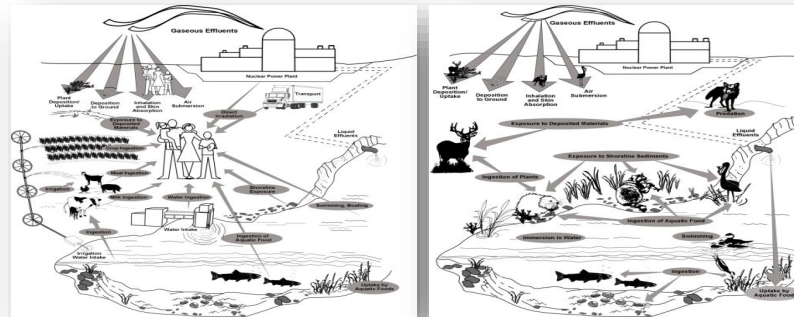
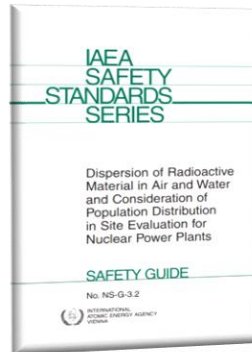
Requirement 24: Evaluation of hazards associated with human induced events

The hazards associated with human induced events on the site or in the region shall be evaluated.



Requirement 25: Dispersion of radioactive material

The dispersion in air and water of radioactive material released from the nuclear installation in operational states and in accident conditions shall be assessed.



Exposure Pathways to Humans and biota

Requirement 26: Population distribution and public exposure

The existing and projected population distribution within the region over the lifetime of the nuclear installation shall be determined and the potential impact of radioactive releases on the public, in both operational states and accident conditions, shall be evaluated and periodically updated.

Requirement 27: Uses of land and water in the region



The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation on the region.

Requirement 28: Monitoring of external hazards and site conditions

All natural and human induced external hazards and site conditions that are pertinent to the licensing and safe operation of the nuclear installation shall be monitored over the entire lifetime of the nuclear installation.



Requirement 29: Review of external hazards and site conditions

All natural and human induced external hazards and site conditions shall be periodically reviewed by the operating organization as part of periodic safety review and as appropriate throughout the operating lifetime of the nuclear installation, with due account taken of operating experience and new safety related information.

Content of SAR

TABLE 1. INFORMATION INCLUDED IN THE SAFETY ANALYSIS REPORT ISSUED FOR DIFFERENT LICENSING STAGES OF THE NUCLEAR POWER PLANT

Chapter of the safety analysis report	Licensing stages		
	Site permit: Initial SAR	Construction permit: Preliminary SAR	Commissioning: Pre-operational SAR (final SAR)
1 Introduction and general considerations	Preliminary information	Final information	Verified and updated information
2 Site characteristics	Final information	Verified information	Verified and updated information
3 Safety objectives and design rules for structures, systems and components	General design requirements	Design requirements specific to the reactor type	Verified and updated information
4 Reactor	Description of an envelope and general requirements for a given part of the design of SSCs	Description of SSCs and requirements for the operation of systems	Verified and updated information
5 Reactor coolant system and associated systems	Description of an envelope and general requirements for a given part of the design or SSCs	Description of SSCs and requirements for the operation of systems	Verified and updated information

TABLE 1. INFORMATION INCLUDED IN THE SAFETY ANALYSIS REPORT ISSUED FOR DIFFERENT LICENSING STAGES OF THE NUCLEAR POWER PLANT (cont.)

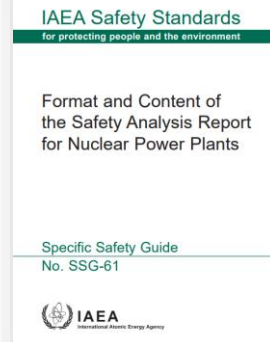
Chapter of the safety analysis report	Licensing stages		
	Site permit: Initial SAR	Construction permit: Preliminary SAR	Commissioning: Pre-operational SAR (final SAR)
19 Emergency preparedness and response	General requirements for the emergency preparedness	Description of emergency facilities and emergency plans	Updated description of the emergency facilities and emergency plans
20 Environmental aspects	Preliminary or expected information, consistent with the report on the environmental impact assessment	Updated information, referring to other parts of the SAR	Updated information, referring to other parts of the SAR
21 Decommissioning and end of life aspects	General requirements for decommissioning and end of life aspects	Preliminary information for decommissioning and end of life aspects	Updated information for decommissioning and end of life aspects

Note: SAR — safety analysis report; SSCs — structures, systems and components.

Typical Table of Contents of a Site Report or Site Characteristic Chapter of Safety Analysis Report

CHAPTER 2: Site characteristics

- 2.1. Geography and demography
- 2.2. Evaluation of site specific hazards
- 2.3. Proximity of industrial, transportation and other facilities
- 2.4. Activities at the plant site that might influence the safety of the plant
- 2.5. Hydrology
- 2.6. Meteorology
- 2.7. Geology, seismology and geotechnical engineering
- 2.8. Site characteristics and the potential effects of the nuclear power plant in the region
- 2.9. Radiological conditions due to external sources
- 2.10. Site related issues in emergency preparedness and response and accident management
- 2.11. Monitoring of site related parameters



Typical Table of Contents of Environmental Aspects Chapter of Safety Analysis Report

CHAPTER 20: Environmental aspects

- 20.1. General aspects of the environmental impact assessment
- 20.2. Site characteristics that are important in terms of environmental impact
- 20.3. Plant features that minimize the environmental impact
- 20.4. Environmental impact of construction
- 20.5. Environmental impact of normal operation
 - 20.5.1. Authorized limits and operational targets for discharges and releases
 - 20.5.2. Radiological impacts of normal and abnormal operation
 - 20.5.3. Measures and controls to limit adverse impacts during operation
- 20.6. Environmental impact of postulated accidents involving radioactive releases
 - 20.6.1. Design basis accidents
 - 20.6.2. Design extension conditions
 - 20.6.3. Measures and controls to limit adverse impacts during accidents
- 20.7. Environmental impact of plant decommissioning
- 20.8. Environmental measurements and monitoring programmes
- 20.9. Records of radioactive releases and availability of information to the authorities and the public

IAEA Safety Standards

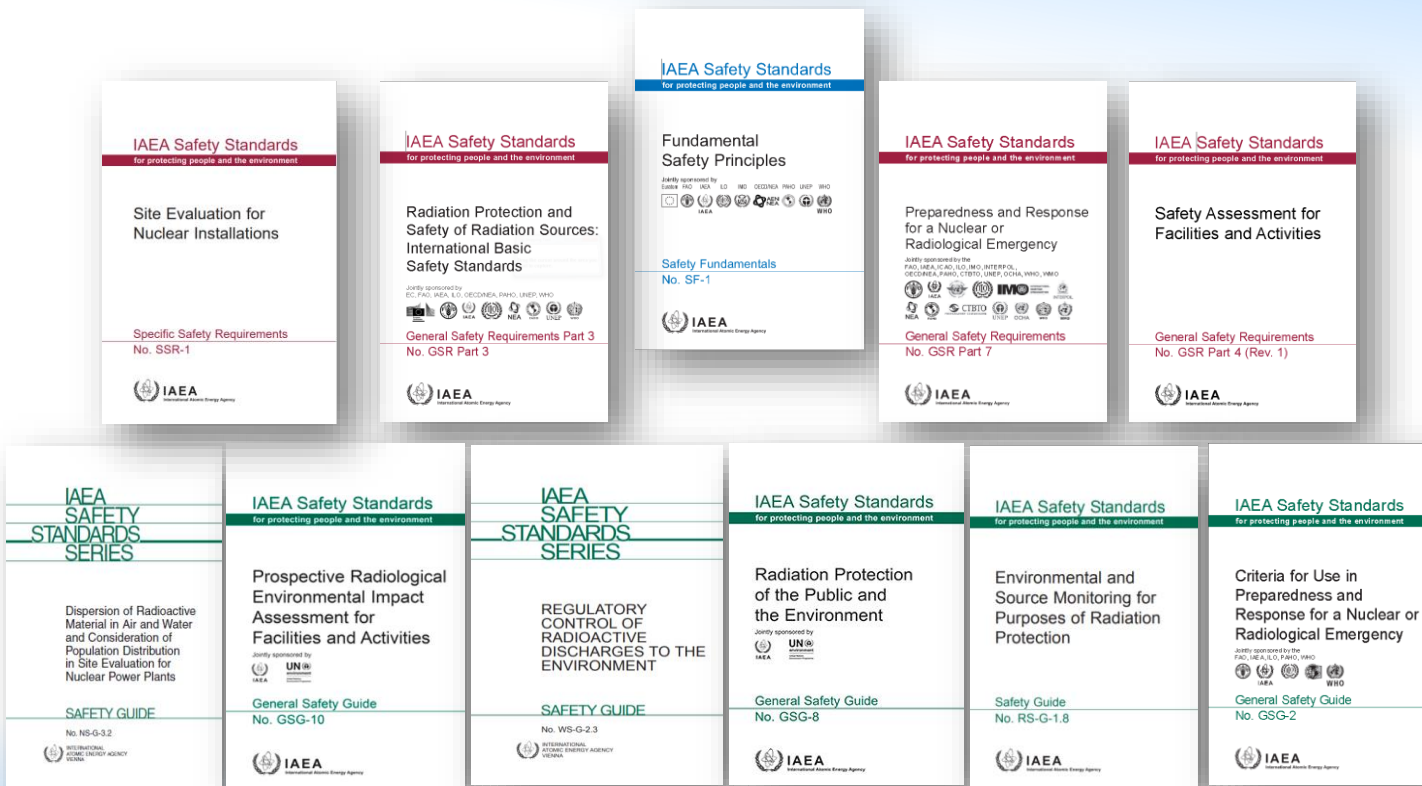
for protecting people and the environment

Format and Content of
the Safety Analysis Report
for Nuclear Power Plants

Specific Safety Guide
No. SSG-61



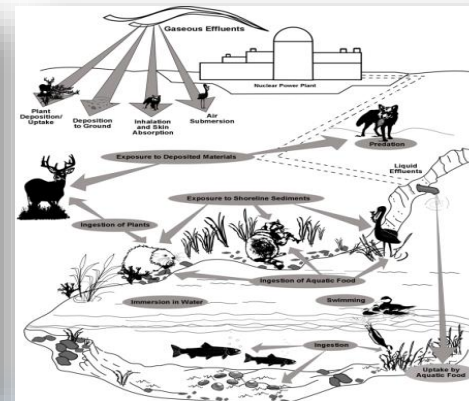
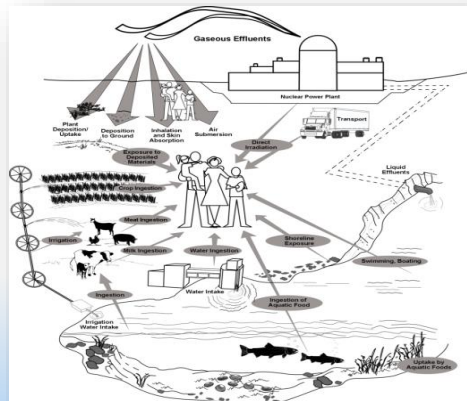
IAEA Safety Standards related to EIA



NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for NPPs

- The purpose of the NS-G-3.2 is to provide guidance on the studies and investigations necessary for assessing the impact of a NPP on humans and the environment.
- It also provides guidance on the feasibility of an effective emergency response plan, in consideration of all the relevant site features.

Exposure Pathways to Man and Biota



IAEA SAFETY STANDARDS SERIES

Dispersion of Radioactive
Material in Air and Water
and Consideration of
Population Distribution
in Site Evaluation for
Nuclear Power Plants

SAFETY GUIDE

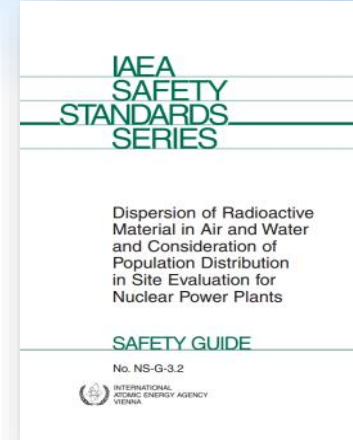
No. NS-G-3.2

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for NPPs



- It provides also guidance on investigations relating to population distribution, and on the dispersion of effluents in air, surface water and groundwater.
- The guidance is intended to help determine whether the site selected for a NPP satisfies national requirements and whether possible radiological exposure and hazards to the population and to the environment are controlled within the limits set by the regulatory body, with account taken of international recommendations.



NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for NPPs

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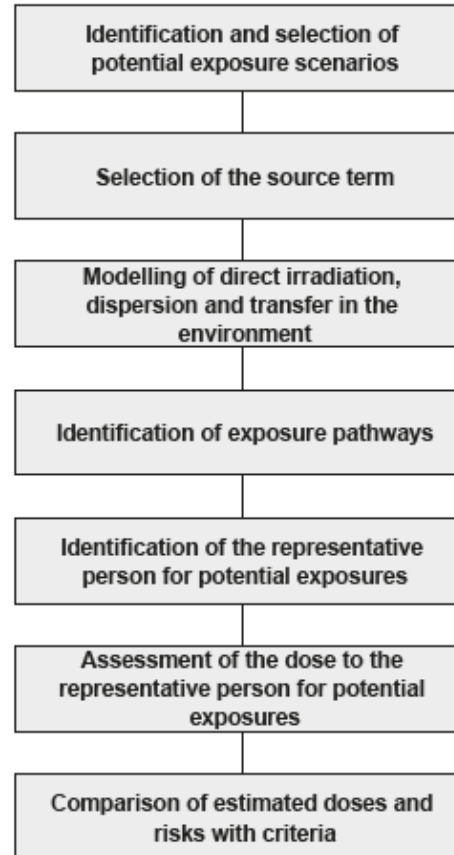
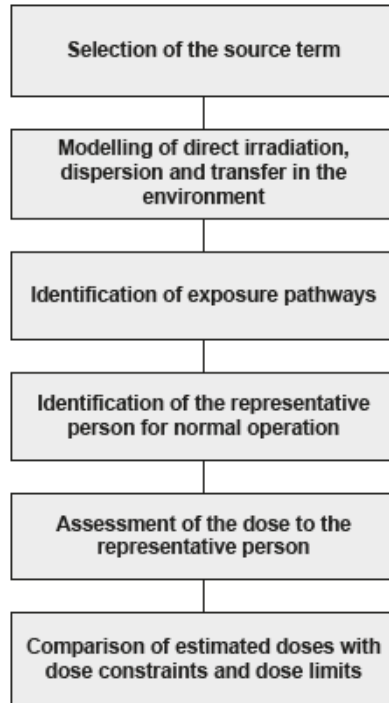
Radiological environmental impact assessment

- The aim of a radiological environmental impact assessment is to determine whether the planned installation complies with current legislative and regulatory requirements on the protection of the public and the environment under all reasonably foreseeable circumstances.
- REIA includes the consideration of exposures expected to occur in normal operation and potential exposures due to accidents that are identified and characterized by means of a safety analysis.

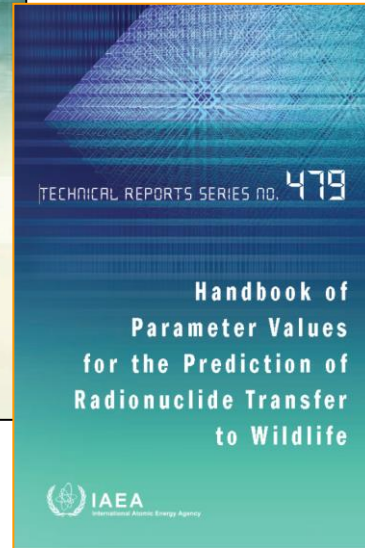
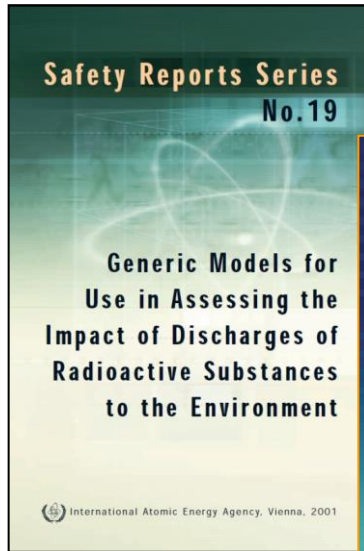
Radiological environmental impact assessment

- There are factors which are important for conducting the radiological environmental impact assessment, such as the source term, the characteristics of the installations, the characteristics of the location, the expected doses, the national licensing regulations for the particular installations, and the stage in the authorization process.

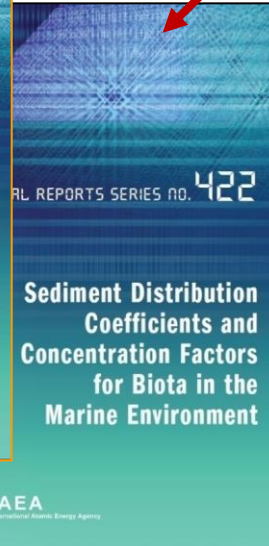
Methodology for radiological environmental impact assessment



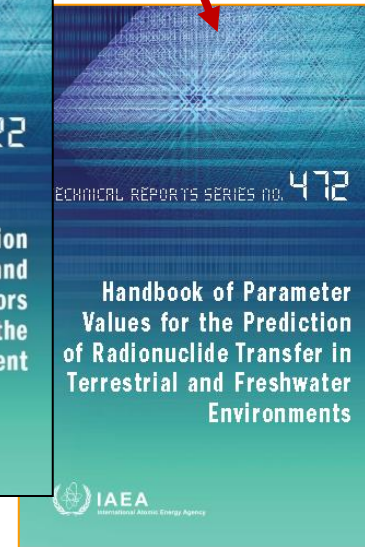
IAEA Supporting Documents



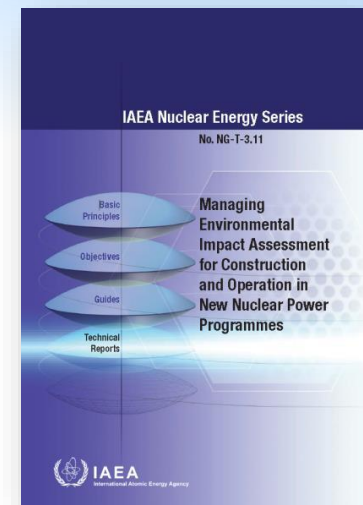
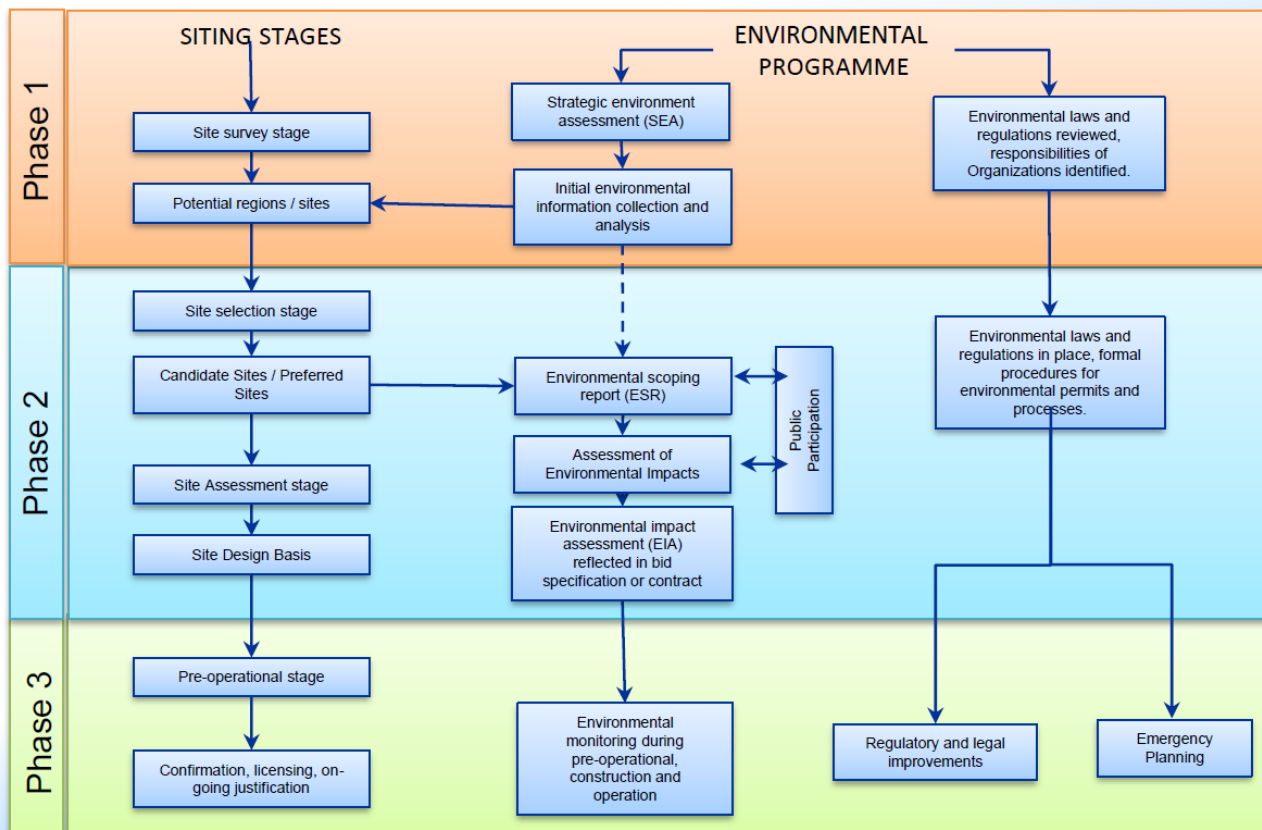
For assessing dose
rates to wildlife



For assessing dose
to humans

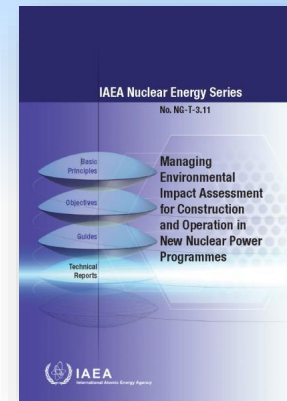
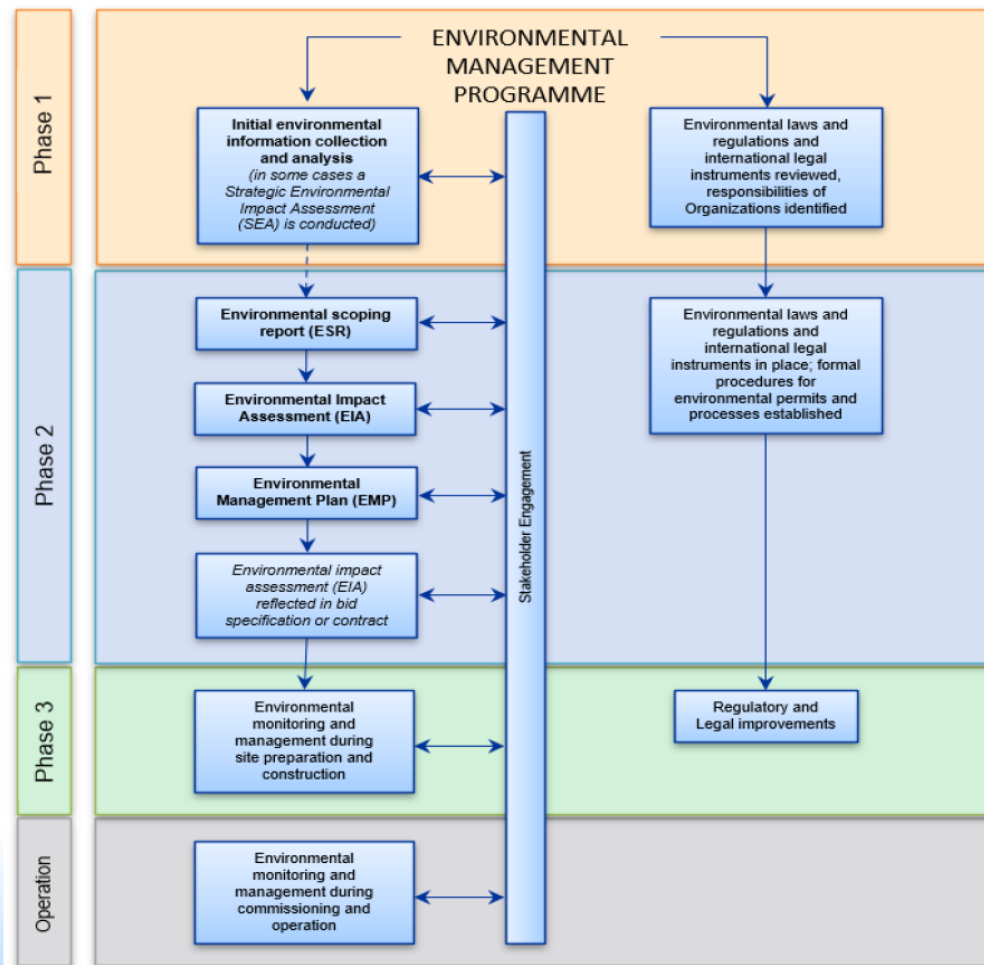


Phased approach to address environmental issues in new nuclear power programmes



Managing EIA for Construction and Operation for New Nuclear Power Programme (NG T 3.11) Rev. 1

Phased approach to environmental protection



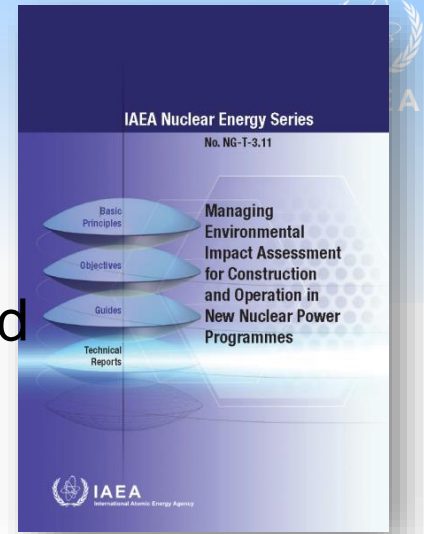
Typical Content of the Environmental Scoping Report



- Introduction
- Project justification
- Description of the EIA process
- Description of the project
- Alternative options to be considered
- Scope of the environmental impact assessment report
- Available baseline environmental information
- Baseline environmental data collection
- Methodologies for the environmental impact assessment study
- Public participation plan

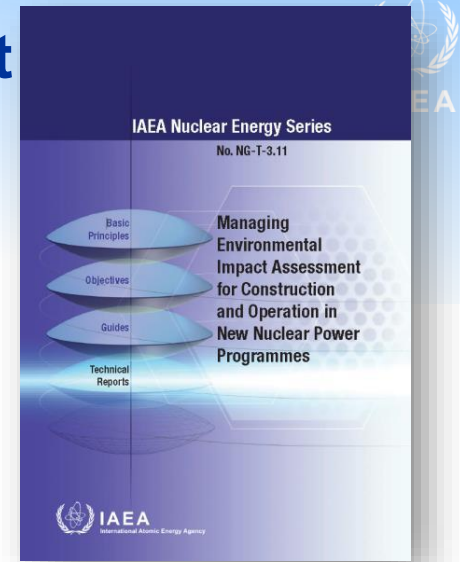
Environmental Impact Assessment Report

- Summary
- Introduction
- Environmental impact assessment procedure and communication and participation
- Description of the project
- Description of the plant
 - Radiological and non-radiological emissions (both atmospheric and liquid);
 - Water and waste issues;
 - Chemicals potentially to be used on-site;
 - Transportation and traffic connections.



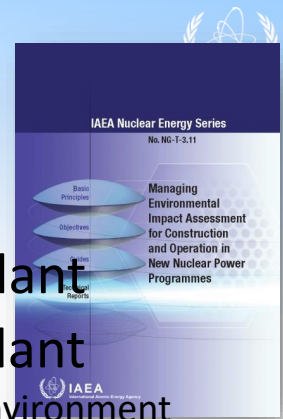
Environmental Impact Assessment Report

- Nuclear safety
- Description of the environment
 - Meteorology and air quality;
 - Land use, buildings and land use plans;
 - Soils, geology and hydrogeology;
 - Water resources and quality;
 - Terrestrial ecology;
 - Aquatic ecology;
 - Existing radiological and conventional contamination;
 - Socioeconomic characteristics of the areas that may be affected by the nuclear power project.



Environmental Impact Assessment Report

- Environmental impact assessment for the project
 - Impact during construction of the nuclear power plant
 - Impact during normal operation of the nuclear power plant
 - Impact during decommissioning of the nuclear power plant
 - Air, soil and water quality due to nuclear and non-nuclear releases to the environment
 - Aquatic flora, fauna and ecological values
 - Terrestrial flora, fauna and ecological values
 - Landscape and cultural environment
 - Traffic
 - Noise level
 - People and socioeconomic factors
 - Waste management
 - Spent fuel management
 - Cumulative impact
 - Impact of irregular operation and accidents at the nuclear power plant
 - Transboundary impacts (depending on States)
 - Nuclear fuel production chain
 - Prevention and mitigation of adverse impacts
 - Environmental monitoring programme



Overlaps between EIA and Site Licensing

- Geography of the site
- Demography such as nearby and regional populations, sensitive subpopulations
- External hazards that could impact the site
- Meteorology, including discussion of the characteristics describing dispersion of airborne contamination
- Surface water and groundwater, including modelling of dispersion
- Radiological consequences
- Radiological monitoring programme
- Feasibility of implementation of emergency planning

Final Remarks

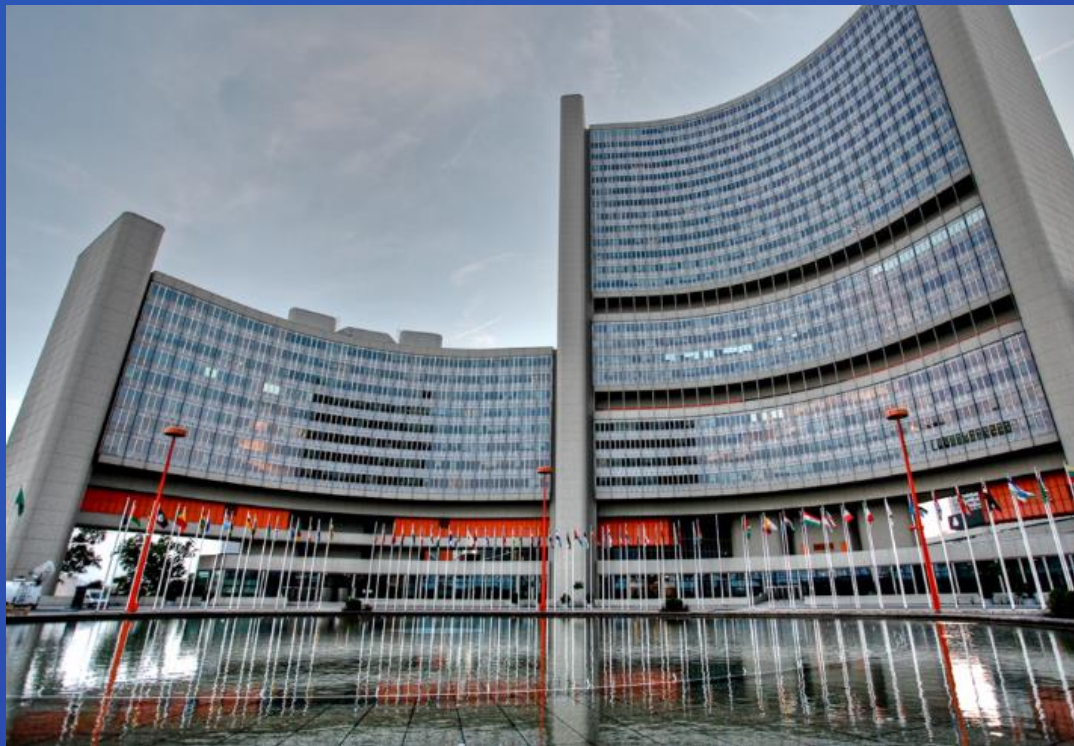
- For a nuclear installation project, environmental impact assessment report is very broad and it includes also **radiological environmental impact assessment**.
- The authority to which such a report should be submitted is typically a ministry of the environment or an environmental authority.
- Regulatory body for radiation protection and nuclear safety in MS should contribute to the review of the environmental impact assessment report in its field of responsibility.
- Interfaces, roles and coordination among other organizations involved in the environmental impact assessment should also be taken into consideration.

Final Remarks

- Legal relation between environmental impact assessment and the licensing process should be established.
- The license and permit processes for nuclear installations for the purpose of the EIA report should be described in the legislative framework.
- Measurable parameters and respective quantifications should be established as much as possible to define whether the applicant submissions comply with.
- Conditions can be based on discharge limits, but they can also be outcome based.
- The future operating organization prepares, and the regulatory body approves an environmental management plan.

Final Remarks

- The purposes of the environmental management plan are to ensure that the environment is properly considered during pre-construction, construction, operation, and decommissioning of the nuclear installation, to minimize or prevent the negative impacts, and to enhance the positive impacts.
- The environmental management plan is a comprehensive document that identifies, among others, the actions to be taken (including any mitigation measures that are included in the environmental impact assessment report and licensing conditions imposed by the regulator), responsibilities, reporting, and processes for implementing corrective actions if needed.
- Some States may not require such a combined document but instead may require individual plans for specific issues.
- The environmental monitoring programme should be a part of the environmental management plan.



Thank you!
Questions?

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